A STRATEGIC APPROACH TO THE CONCEPTUAL DESIGN OF COMPLEX RADWASTE FACILITIES

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ABSTRACT

The design of radwaste treatment facilities is often complicated by the variety of waste types being treated. Further uncertainties over their composition and final waste form specifications can make the normal conceptual design phase difficult and unreliable.

This paper describes the strategic planning necessary to define the facility functions and the process to prepare a Functional Design Criteria. The paper shows clearly, that for complex waste management problems, it is vital to consider and resolve uncertainties by means of a strategic plan before embarking on conceptual design. The paper shows an approach to preparation of design criteria using functional analysis. The paper provides examples where these methods were and are being used, both in the U.K. and the U.S. Strategic plans and functional criteria can be used as a basis for conceptual design which then provides a more meaningful basis for detailed technology selection during the detailed design process.

The paper discusses experiences and lessons learned in the planning process. This process is widely applicable to a number of complex waste treatment facilities being planned and developed to process wastes generated at government facilities.

INTRODUCTION

As part of the early planning for large, complex radioactive waste treatment facilities, a strategic planning activity takes place. This activity sets the approach for development of the facility and combined with a functional analysis develops the design criteria for facility design. As with most projects, there are a large number of unknowns and much uncertainty, both in desired functions, budget availability, and regulatory environment. A systematic approach to define and resolve uncertainties and develop design criteria is necessary to ensure a successful outcome.

Task Definition and Objective

A statement of objectives is prepared including a summary of the potential desired functions of the facility and the planning activities to be undertaken. The specific sub-tasks are defined, a budget and schedule prepared. Interfaces, both physical and programmatic (organizational), are defined including identifying reporting and review relationships.

A summary is prepared of all data covering the potential wastes for processing and final disposal specifications (waste acceptance criteria).

Preliminary Work

An initial planning meeting is held with the client, or the technical representative, to review the data gathered, and the task definition, objectives, working relationships, and schedule.

Mission Logic Diagrams (Fig. 1) are compiled to provide a process scenario which will achieve the satisfactory disposal of all the wastes within the project scope. These diagrams are again reviewed with the client and represent a first approach not only for strategy but for identification of uncertainties. Sometimes it may be possible during this early phase, using this approach, to significantly modify the Task Definition and Objective of the project.

Strategy

An initial review of the uncertainties is conducted. The uncertainties are defined as best known at the time. A plan is produced as to the activities to overcome or resolve the uncertainties. Preliminary strategic functional flow diagrams are prepared. Periodic meetings are conducted with the client (technical representative) to review technical work progress and resolve open items and questions. Assumptions necessary to continue the work are documented along with changes in strategy or facility functions during the process. Assignments for further work activities (work plan and changes) are reviewed and documented.

Functional Analysis

An initial analysis or definition of functions is prepared at least to the third level of functions (Function Tree, Fig. 3). The functions are related in the form of functional flow diagrams which show interfaces, inputs, output functions, resources and controls or constraints. The functional analysis approach is depicted on the functional flow diagram, Fig. 2. The steps include defining the mission, decomposing the facility functions, assigning or developing requirements for each function, describing the physical facility or portion to resolve the functional requirements, and combining the information into a functional requirements document or functional design criteria.

Process Flow Diagrams

A process flow (bubble) diagram is prepared showing the first level of a process route (steps) for each waste type, from entry to the facility to exit to the appropriate disposal facility. The flow diagrams are produced for each level of process. These diagrams are iterated with the functional analysis activities and form the basis to describe the architecture (physical arrangement and systems/equipment) of the facility. A typical first level process flow diagram is shown in Fig. 4.

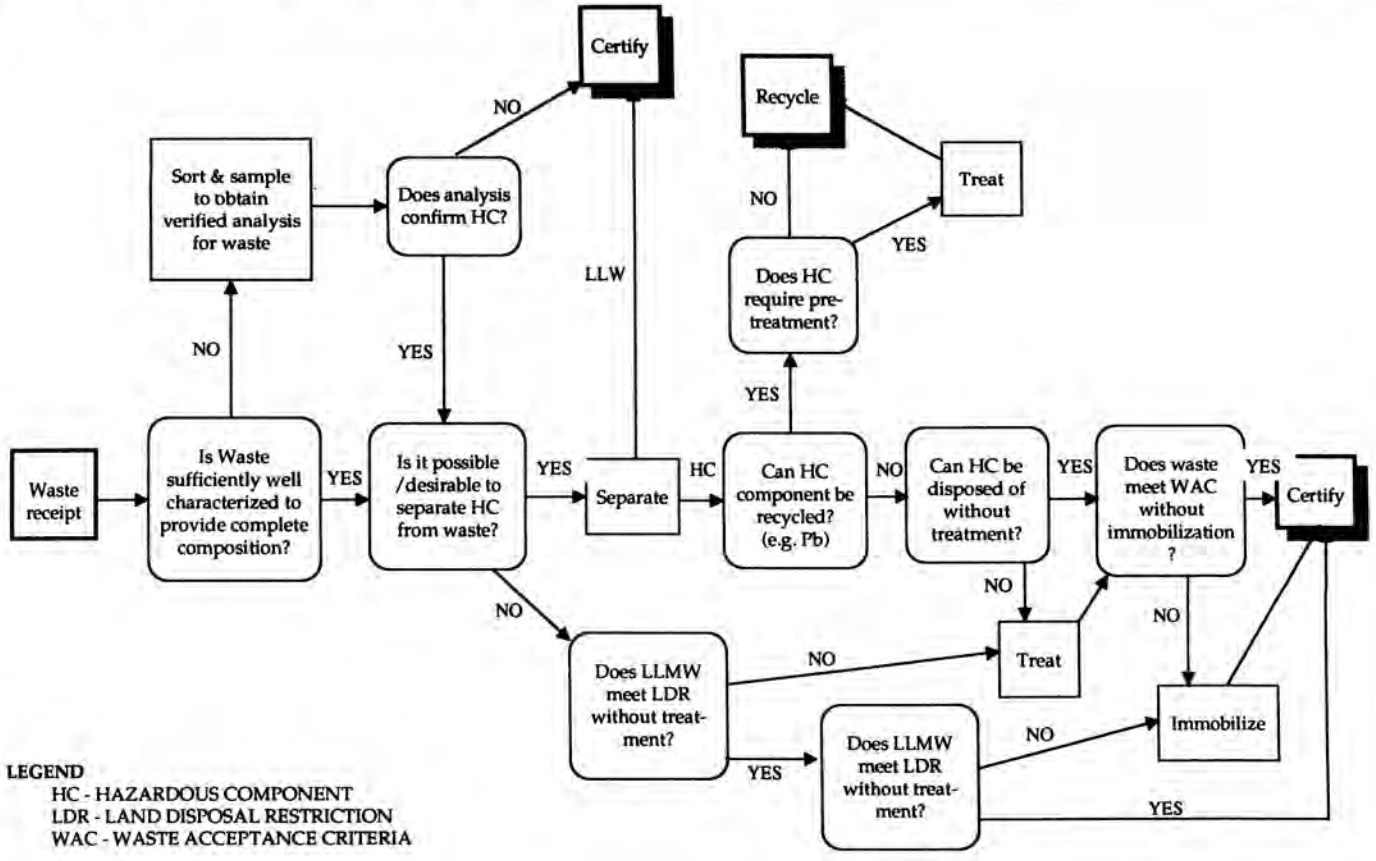

Fig. 1. Mission logic diagram.

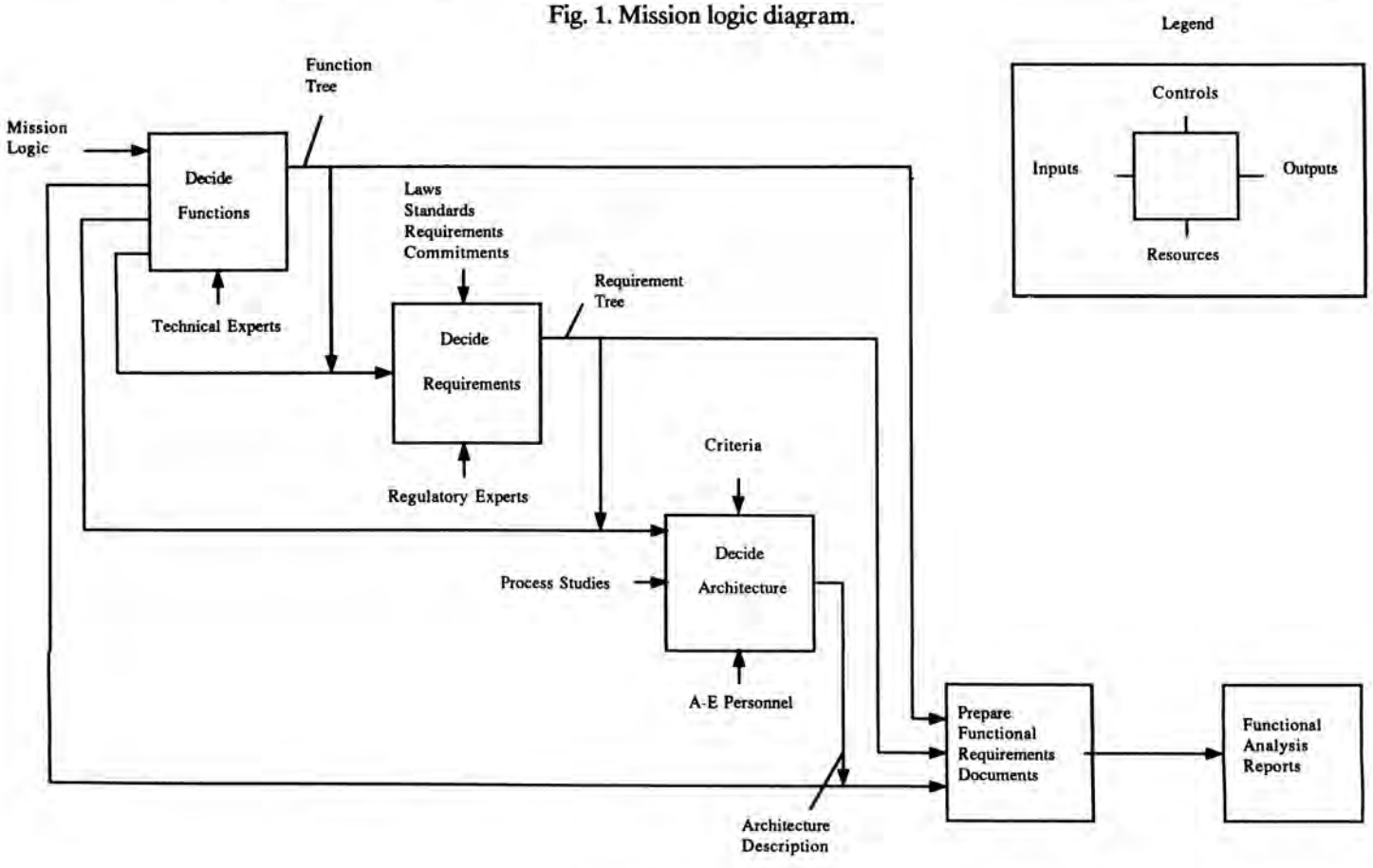

Fig. 2. Functional analysis approach.

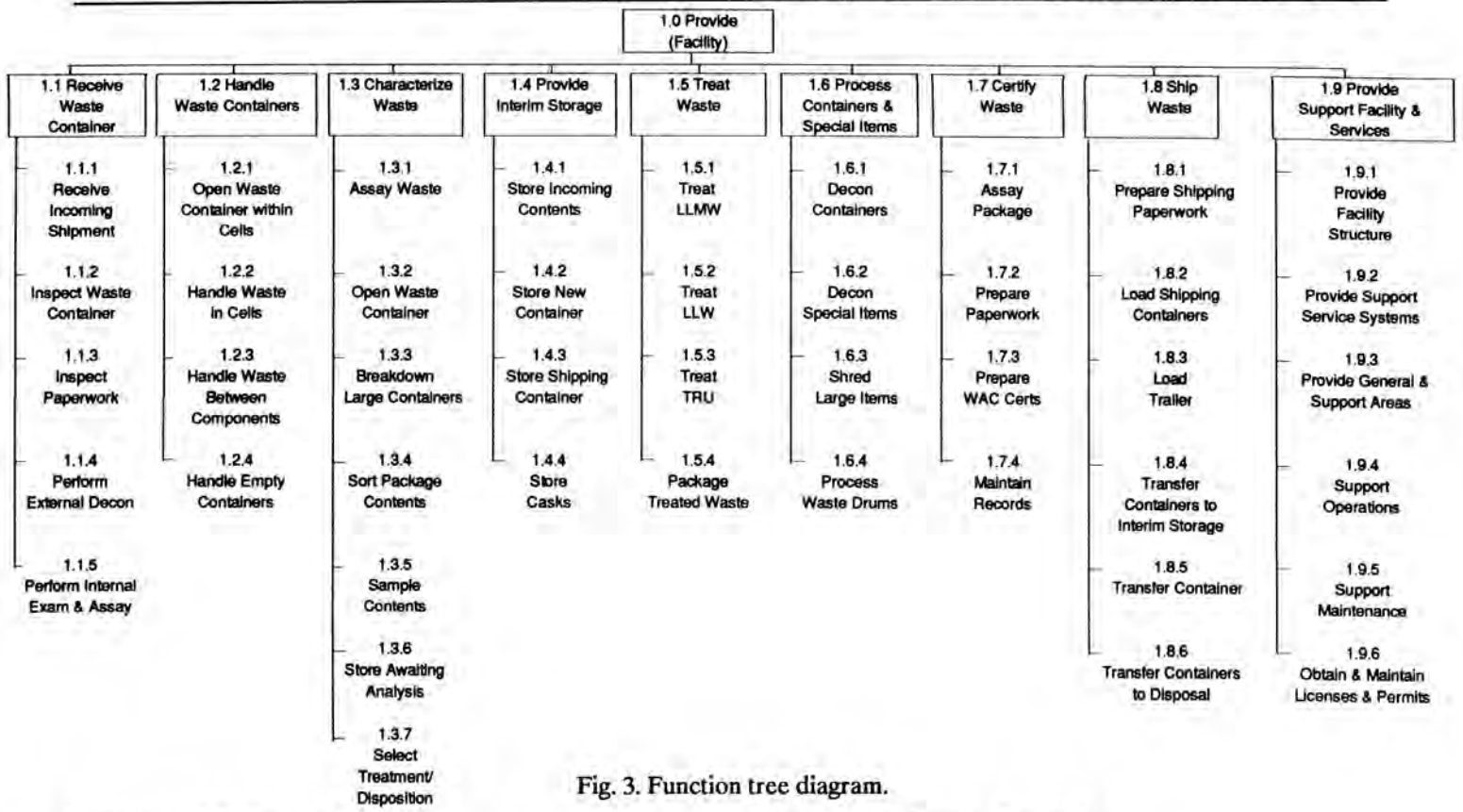

Fig. 3. Function tree diagram.

Process and Technology Analysis

A work plan is prepared to review the potential processes and technologies applicable to the major steps in the process flow diagrams. The work plan is reviewed with the client (technical representative). A technology assessment is conducted for each of these steps. For example, methods of non-destructive examination and assaying of waste containers where the contents are unknown are evaluated. Various methods are reviewed based on capability, experience, cost and physical compatibility.

Output

A report is drafted summarizing the work performed including the overall strategy, facility functions, initial functional requirements, facility architecture, process flow diagrams, major assumptions, remaining uncertainties, and proposed strategy for resolution. A thorough review of the draft report is undertaken by the project team and the client (technical representative).

Typical recommendations which may emerge from this kind of report will be answers to generic questions such as:

1. Is it desirable to separate LLW from LLMW if treatment processes are required before disposal?
2. Is it sensible to receive and process TRU waste along with LLW waste?
3. Is it more cost effective to build engineered LLMW facilities to house untreated LLMW waste than to deactivate these wastes thereby allowing standard shallow land burial?
4. For the preferred systems which technologies need further development?
5. Is extensive sorting at an early stage more desirable than mass processing?

Examples and Lessons Learned

A number of radwaste projects within BNF plc have been tackled using this strategic approach. In addition, this basic approach was recently used in the Strategic Assessment phase of the pre-conceptual planning for a U.S. government waste receiving and processing facility. Suggested refinements in the approach have been proposed in this paper to aid in future projects.

Within BNF plc, the Waste Treatment Complex (WTC) was designed to accept current waste generated and backlog Plutonium Contaminated Material (which approximates TRU waste in the U.S.). WTC will receive, sort, condition (treat), and repackage waste for disposal or storage. The facility has been designed and constructed. It is currently in a lay-up condition until recent changes in regulatory requirements are resolved. During the development of WTC, the wastes to be treated were evaluated for nuclide content, physical constituents and packaging. An estimate of the backlog and the current (planned) generation of new materials were compiled together with an assessment of disposal options. WTC was initially designed for the sea-dump route but the moratorium in sea-dumping in the early 1980s resulted in a reappraisal and revision of disposal philosophies. Detailed discussions in the early planning stages were conducted between the design project team (including operations, maintenance, R&D, safety and design personnel) and the client (the operating group, management). Input from specialists, such as Safety and R&D, was solicited. A preliminary design concept was established and uncertainties in design and technology were identified. Uncertainties were tackled through a range of activities such as development tasks. The design concept was then reassessed (iterated). Flow diagrams evolved into a more detailed design for plant components. A

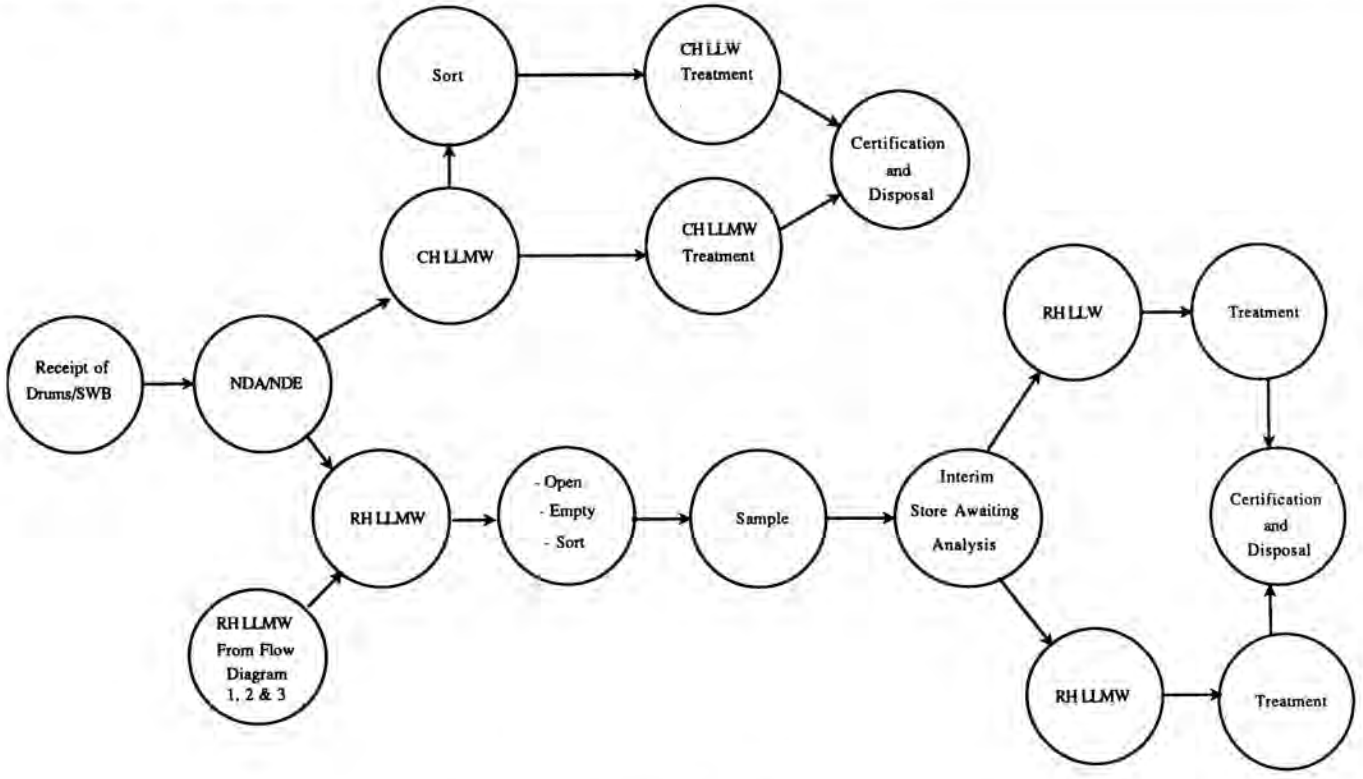

Fig. 4. Process flow diagram.

vital stage was review by a design committee which included the design team, the client and appropriate specialists.

The same approach was used again in Britain to integrate and coordinate the management and disposal of its Intermediate and Low Level Wastes. The problem of Intermediate Level Wastes (ILW) was highly sophisticated with a wide diversity of candidate waste types for disposal. Strategic analysis identified a Product Evaluation Program which evaluated the applicability of all available disposal matrices to the wastes.

This program took five years to complete and its recommendations gave rise to the family of treatment facilities which are currently operating or under construction at Sellafield.

A similar approach has recently been utilized for strategic assessment activities on a U.S. government waste processing facility project in the pre-conceptual design stage.

The facility is intended to provide treatment for selected radioactive solid wastes currently stored at a U.S. DOE site. The objective of the pre-conceptual design stage was to recommend a strategy for the receipt, processing, and disposal of the wastes. By using the strategic approach to system design, it was possible to make recommendations which significantly altered the course and scope of the project.

By characterizing and grouping the waste streams and considering current waste disposal options it was possible to generate a series of first level flow diagrams which described the processing of all wastes. A logic diagram format (see Fig. 4) was generated to screen and group each individual wasteform. This provided the basis for each flow diagram.

The flow diagrams were used to define the number and scope of treatment options. This enabled the formation of a waste plan to review the candidate process and technology options applicable to each process line.

This study eventually concluded that the processing of these wastes was impractical under one project. Diverse waste characteristics and stringent disposal criteria made it clear that segregation of the solid wastes into contact-handled and remote-handled fractions was sensible and the scope of the project was significantly altered in preparation for the Conceptual Design Phase.

The existence of this strategic work continues to provide project assistance to review the changing inventory of wasteforms which will inevitably appear as candidates for processing.

Its wide applicability makes it ideally suited to most Waste Management missions in the nuclear sphere.

REFERENCE

Figure 2 in this paper was adapted from Fig. 1 in a similar paper "Application of Systems Engineering in the Development of the Federal Waste System", Jackson Hole, William Lemeshewsky.